F. H. Edmunds

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PAPER 49-15

SOME CRETACEOUS SECTIONS ALONG ATHABASKA RIVER FROM THE MOUTH OF CALLING RIVER TO BELOW GRAND RAPIDS, ALBERTA

(Report and Figure)

By

R. T. D. Wickenden

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Illustration

Figure 1. Sketch map of area along Athabasca River in Alberta, showing positions of bedrock outcrops and geological sections examined --- In envelope.

Some Cretaceous Sections along Athabasca River from the Mouth of Calling River to below Grand Rapids, Alberta

INTRODUCTION

This report is based on an examination of bedrock sections exposed along Athabasca River between Calling River and a point about 5 miles below Grand Rapids. The field work was done during August 1947, chiefly for the purpose of collecting material for microfossil studies such as might facilitate the correlation of formations hitherto recognized only in well sections.

Acknowledgments

The writer was ably assisted in the field by R.B. MacLeod, student assistant. Frederick Meyer rendered valuable services as boatman and guide, and many residents gave freely of their services and hospitality. The writer also acknowledges the help and useful advice given him while preparing for the trip, by Frank M. Pherrill, Forest Ranger at Athabasca, Alberta.

The rock sections examined, range from the base of the Grand Rapids formation up to the basal beds of the Lea Park. Not all parts are well exposed, and time did not permit detailed studies of some of the best sections, as, for example, those of the lower part of the Grand Rapids formation. Sufficient information was obtained, however, to correct some misconceptions about the character and thickness of the formation and to establish correlations with strata known only in well sections in the Plains.

Previous Work

No detailed accounts have been written on the geology of the area examined. Three reconnaissance reports have been published: one by Robert Bell in 1884, another by R.J. McConnell in 1893, and one by F.H. McLearn in 1917. Bell's report is very generalized, mentioning the occurrence of Cretaceous strata and a few of their features. McConnell briefly described some of the formations, gave them names, and gave the location of some of the outcrops. McLearn's report included a short description of the formations

and data on their thickness and origin. A correlation of the formations and an indication of the position of the boundary between the Upper and Lower Cretaceous series at the top of the Grand Rapids formation were made by McLearn in a later report (1919, pp. 2 and 3) on the formations of the lower Smoky River. More recently, however, this boundary has been raised by McLearn (1932, p. 168) to the top of what was then called the Pelican shale, for which the name Joli Fou formation is proposed in the present report.

The accompanying table gives the thicknesses of formations studied by the writer and the names he proposes to use. The part of the Upper Cretaceous series above the Pelican formation was not well enough exposed to permit accurate measurements of thickness, and has been referred in the table to the Colorado group; some parts of this section, however, are described elsewhere in this text. It is probable that more detailed studies may show that the names of formations of equivalent age in eastern Saskatchewan and Manitoba may also be applied in the Athabasca region.

The Labiche formation was intended originally to include all marine shale beds from the top of the Pelican formation to the base of sandy, non-marine formations about 1,100 feet above. The top, however, was not well defined. It was known that equivalents of the 'Pierre' and 'Colorado' were included in these shales, but it was supposed that these could not be separated in this region as they had been elsewhere on the Plains. The result of the examination of the section along the Athabasca in 1947 shows that the formations there can be differentiated and that, consequently, the term Labiche can be discarded.

Description of Formations

Table of Formations

Age	Name	Lithology	Thickness in Feet
Upper Cretaceous	Lea Park	Shale, dark grey with few bentonite beds; lower 20+ feet very fissile and platy	Only lower 75 feet studied in detail
	Colorado group	Shale, medium and dark grey; two members of calcareous speckled shale at top separated by non-calcareous shale with another non-calcareous shale member at base	250+ (middle part of section incomplete)
	Pelican	Sand; some dark grey shale beds; few pebbles near top and bottom	40±
Upper or Lower Cretaceous	Joli Fou	Dark grey, non-calcareous shale	100-110
Lower Cretaceous	Grand Rapids	Mostly sand and silts; lower 130 feet very massive sand and sandstone member	360±
	Clearwater	Shale, dark grey, sandy at top, with much glauconite	Only 5 to 10 feet at top studied in connection with this field work

The discussion of the formations, which follows, is arranged in descending order from the youngest to the oldest to correspond with the section encountered in drilling.

Lea Park Formation

The original definition of the Lea Park, by Allan[1] (1918, pp. 10, 11), described the upper 375 feet of the formation; the lower part is not exposed in the central Plains and has only been described from samples obtained in drilling oil and gas wells. Some of the sections along the

[1] Dates, etc., in parentheses are those of references listed at end of this report.

Athabasca show some of the basal part of the Lea Park; only this part is described in the present report as higher beds are not well exposed and time was not available to attempt to determine the relationship of the scattered sections.

The best section of some of the basal beds of the Lea Park was observed on the west side of the river at a small rapid known as Swift Current, practically at the north boundary of NW.¼ sec. 13, tp. 72, rge. 19, W.4th mer. At this exposure there are steep cliffs along the river, and above them a partly covered bench from which rises another cut bank about 70 feet high. This bank exposes about 60 feet of the Lea Park almost at the base of the formation. The upper 25 feet of the exposure is dark grey, blocky, fractured shale, with large septarian concretions scattered throughout. These concretions are as large as 3 to 4 feet in diameter, and up to 2 feet thick. A few fossils, mostly Baculites and gastropods, were found in the concretions as well as in the shale. The lower 30 feet of the Lea Park exposure is made up of similar shale carrying a few small concretions. Baculites and a few gastropods were found in this part of the section. Below the section for 35 feet, talus covers the shale down to beds just above the speckled shale of the Colorado group.

A few fossils were collected from the Lea Park shale and the contained concretions, and these have been studied by F.H. McLearn of the Geological Survey, who identifies them as follows:

Apporhais n. sp.

Drepanochilus ? n. sp.

Baculites ovatus Say var.

Dr. McLearn remarks: "I have not been able to find reference to the two species of gastropods anywhere else in North America. The Baculites shows a tendency to vary towards the variety haresi Reeside, but has thicker and more ovate inner whorls than that variety. Although

from the 'Lea Park', this fauna may occupy a lower horizon than the Lea Park fauna from outcrops on North Saskatchewan River and the adjacent area".

Below the covered part of the section and just above the calcareous speckled shale, are a few feet of nearly black, flaky shale overlain by a band of bentonite. This shale will be referred to again in describing the lower section; it is uncertain whether it should be included with the Lea Park or with the formation below.

The zone of large concretions near the top of the section described seems to be fairly continuous and, therefore, a fair local horizon marker for some distance upstream. It disappears beneath the valley in the vicinity of the mouth of Labiche River.

Other exposures of the Lea Park were scattered between Labiche River nd the town of Athabasca. Most of them are badly slumped, and it is doubtful if a complete section can be studied in the area.

Colorado Group

The beds beneath the Lea Park formation and above the Pelican formation appear to be incompletely exposed along the Athabasca. Feniak's log (1944, pp. 4, 5) of Athadome No. 2 well near the town of Athabasca indicates that the beds between 710 and 1,460 feet represent this part of the Upper Cretaceous series, a total of 750 feet. Possibly the upper 100 feet and the basal 200 feet, with a few scattered small sections in between, were observed by the writer, but these did not permit a subdivision of these beds into proper formations. The term Colorado group has been widely used in the United States to include formations that lie between the top of the Niobrara and the top of the Dakota. Because both the lithology and the age of the formations on the Athabasca correspond to some extent with the formations included in this group, the term is applied here. The term 'Alberta group' was considered, but its use seems better confined to formations in the Foothills where the age and lithology differ from those in the Plains. Nauss' (1945) term, Lloydminster formation,

although applying to strata with the same upper contact, includes the equivalent of the Pelican and Joli Fou formations, which underlie the Colorado and may be in part of Lower Cretaceous age.

The exposures of the various parts of the Colorado group occur from about 2 miles above Swift Current to the vicinity of Joli Fou Rapids. The contact with the Lea Park probably goes below river level within a mile or two of the mouth of Calling River at an elevation of about 1,605 feet above sea-level or a little higher. If the formation is as thick on the Athabasca as in the Athadome well, it requires a southerly slope of more than 11 feet to the mile to bring the bottom of the formation to the surface at Pelican Rapids. The dip at Swift Current does not seem to be as great as that and, consequently, either the formations that comprise the Colorado group are not as thick in this area as near Athabasca town or in some places the dips are greater than 11 feet to the mile.

A good exposure showing the upper 59 feet of beds of the Colorado group appears in the cliff along the west side of the river at Swift Current. The top of this section is about 34 feet below the base of the section of Lea Park from this locality already described.

	Thickness (in feet)
Lea Park or Colorado	
Bentonite, light grey to cream.....	0.2
Shale, dark grey to black, flaky, non-calcareous; oyster zone near base.....	10.0
Colorado group	
Shale, dark grey, grading downward into medium grey, with white specks of calcareous material; becomes almost an impure limestone near base. Fossils fairly common, especially near the base...	49.0

Fossils were collected from this outcrop, and F.H. McLearn of the Geological Survey identified them as follows:

Inoceramus cf. cardissoides Goldfuss

Ostrea congesta Conrad?

Scaphites ventricosus Meek & Hayden

Baculites cf. asper Morton

These fossils are fairly numerous in the lower part of the section. The Baculites and Scaphites are mostly crushed, but enough specimens were collected to make identification certain. The fossils indicate that these beds belong to the topmost zone of the Colorado group, where Inoceramus of the lobatus - cardissoides species group occurs with Scaphites ventricosus.

Most of the same fossils preserved in much the same condition were found by McLearn (McLearn and Wickenden, 1936, pp. 6 and 7) in the upper speckled shale in the Hudson Bay Junction area, eastern Saskatchewan. The similarity of fossils and lithology at the two localities indicate the same horizon. The widespread occurrence and similarity of material suggest that these beds were deposited when conditions were very uniform over much of what now comprises the Prairies. These circumstances suggest that this horizon is probably one of the most reliable for determining local and regional structures in Upper Cretaceous formations.

Some beds a little lower in the Colorado group were observed in exposures on the north side of the river, where it makes a sharp easterly turn in the southern part of sec. 5, tp. 73, rge. 18, W. 4th mer. Some burnt shale occurs in the cut banks at this place which is locally known as 'Red Mud' or 'Red Rock'. Although considerable slumping is in evidence at this locality, there is some indication that the speckled shale continues downward for at least another 50 feet.

Several other outcrops occur in this vicinity and intermittently to near Duncan Creek, and had time permitted more study probably much more information would have been obtained about the upper part of the Colorado group.

Although outcrops are fairly common between Duncan Creek and Pelican Rapids, most of them are slumped or only show a few feet of beds. Some of the outcrops near the centre of sec. 17, tp. 74, rge. 18, W. 4th mer., on the west bank of the river, expose 15 feet of medium grey, silty

shale, with a few small, round concretions, underlain by 12 feet of dark grey shale with ironstone concretions up to 3 feet in diameter. Similar beds were observed on the east bank of the river in $\frac{S}{2}$ sec. 29, tp. 74, rge. 18, W. 4th mer., where about 12 feet of beds show the following section:

	Thickness (in feet)
Sand, with some shale, thin bedded, medium grey.....	4.5
Sandstone, brownish grey, with many fragments of fish bones.....	0.75-1
Sand, medium grey, with thin shale beds.....	3.0
Shale, dark grey to black, with ochreous or melanterite encrustration; some large concretions at base. Examination of samples show that some of the beds are of speckled shale.....	4.0 to 5.0

A loose concretion at this locality yielded fossils that were identified by F.H. McLearn as Prionotropis of woolgari Mantell and Placenticeras ? sp. These indicate correlation with the Blackstone formation of the Foothills and the Favel of Manitoba.

About a quarter of a mile north of the section described, another small exposure on the east bank shows:

	Thickness (in feet)
Shale, dark grey, with large concretions; few sandy beds.....	15.0
Bentonite, light grey.....	0.25
Silt, medium to light grey.....	1.50
Shale, dark grey.....	1.25
Sand, medium to light grey.....	3.00

At Iron Point, in NE. $\frac{1}{4}$ sec. 6, tp. 75, rge. 18, W.4th mer., on the west bank of Athabasca River, some slumped exposures were studied, but it was impossible to determine where the material originated. A specimen of Inoceramus was collected, and F.H. McLearn reported on it as follows: "Although preservation is too poor for identification, an Inoceramus

with twisted umbone like I. exogyroides M & H is indicated. The ventricosus zone is suggested, but of course not proved."

This occurrence may indicate that the shale at Iron Point may have slid from a considerable distance up the banks.

No exposures were studied in detail between Iron Point and Pelican Rapids. Most of the outcrops are small, and many appear to have slumped. It is possible that more thorough study of the few outcrops in this part of the river may add some information about the age and lithology of beds in this part of the section.

No exposures appear along the Athabasca between Pelican telegraph station and Pelican River, a distance of about 9 miles. A few exposures were observed in the vicinity of Pelican Rapids. The best section of the lower part of the Colorado group can be studied on the east side of the valley near the foot of Stony Rapids, in sec. 30, tp. 79, rge. 17, W.4th mer. At this locality exposures line the side of the valley for nearly half a mile. Although there is much slumping and some mud slides, it was possible to study most of the lower 150 feet of the Colorado group, and to get some information about the beds up to 220 feet above the Pelican formation.

The highest beds in the formation were seen in the north-central part of the exposure referred to above, at the head of a large area of slumped shale and mud slides. At this locality a block that seems to have moved only a short distance shows 10 to 15 feet of dark grey shale, some of which is speckled with calcareous material. Some septarian concretions up to 2 or 3 feet in diameter occur in this part of the shale. Below this point, the section is hidden for about 30 feet to where a bed of light grey bentonite about 4 inches thick surrounded by dark grey, non-calcareous shale outcrops. It is probable that part of the covered section includes the base of the 'lower speckled shale', and is equivalent to the base of the Favel formation of Manitoba and eastern Saskatchewan.

The next lower part of the section was studied in a small gully about 200 yards farther south, at a point about 10 feet lower in elevation than the bentonite bed. This part of the section consists of 20 feet of dark grey shale with some thin partings or beds of light grey silt. In the upper part of the section there are a few crushed fossil shells, apparently a species of Inoceramus.

Below the grey shales, about 10 feet of beds are covered, and another 20-foot section of dark grey shale is exposed, including, about 5 feet from the top, a bed 3 to 6 inches thick of sandstone carrying many fragments of fossil fish. Just below the 20 feet of shale is a prominent bed of sand 1½ to 2 feet thick, containing fish scales and bones. The bed is fairly well cemented, and is a useful horizon marker at many places along the river. The difference in elevation between the base of this bed and the top of the underlying Pelican formation was measured on two occasions with a Paulin altimeter, and determined as 102 to 105 feet. At Stony Rapids, 85 feet of shale are well exposed below this sand bed, but the remainder of the section to the Pelican formation is covered.

When McConnell (1893, p. 28D) examined the section he mentioned the occurrence of "Acanthoceras woolgari" near the base of the Colorado at this locality, but the writer was unable to find any specimens in place, although a fairly good specimen was found in a concretion in slumped shale at 165 feet above the Pelican formation. All specimens seen seem to occur in large concretions, and it is possible that these concretions originated in the speckled shale in the highest part of the section.

In reporting on the fossils collected at this locality, F.H. McLearn pointed out that this ammonite is not an Acanthoceras and not a Prionotropis to which the species woolgari properly belongs. The species belongs to a genus near Acanthoceras, and is of early Turonian-Upper Cenomanian (lowest Upper Cretaceous) age. As the ammonite appears to

originate in beds near the base of the lower speckled shale rather than just above the Pelican formation, as suggested by McConnell, it seems probable that the lower speckled shale is of much the same age as the Favel of Manitoba. Thus, there is still room for beds of Cenomanian age above the Pelican as well as in the Pelican formation itself. A fragmentary specimen of this ammonite was also found about 15 miles farther south, in a broken concretion at the foot of an outcrops on the west bank of the Athabasca approximately in SE.¼ sec. 28, tp. 77, rge. 18, W. 4th mer. This occurrence suggests that the ammonite ranges even higher in the Colorado group. The speckled shale at Stony Rapids is 1,620± feet above sea-level, whereas the elevation of the outcrops in tp. 77, rge. 18, is 1,685± feet. Unless there is a structure, the beds at the latter locality must be higher stratigraphically than at Stony Rapids.

The basal part of the Colorado group and the contact with the underlying Pelican formation were studied a few miles downstream, north of the sharp bend of the river near the boundary between secs. 19 and 20, tp. 8, rge. 17, W.4th mer., and east of this point. The lower 50 feet of the Colorado group and all of the Pelican are well exposed. The Colorado beds comprise dark grey, non-calcareous shales, with a few silt and sand beds. The shale shows encrustations of yellow, ochreous material or melanterite in many places, and some zones show brown, rusty encrustations. Some pyrite occurs in the shale, and it is probable that the encrustations result from the weathering of this mineral. A few concretions were scattered in various parts of the shale, most of them less than a foot in diameter.

Samples of the shale at this outcrop and at Stony Rapids were taken, and the microfossils recovered. Foraminifera are fairly common in the basal 10 feet of shale, less common at 60 to 70 feet above the base, and sparse or missing elsewhere in these lower beds. Most of the specimens are badly crushed and unidentifiable. Samples from the shale above the

fishbone beds contained a few radiolaria similar to some found in the Ashville beds of Manitoba and eastern Saskatchewan.

The foraminifera all have an arenaceous test. Most specimens are distorted, and identification beyond the genus is uncertain. The following list gives some idea of the ones found in this part of the Colorado group:

Haplophragmoides sp., all specimens badly crushed.

Ammobaculites sp., part of the specimens resemble those that have been called A. tyrrelli by Nauss or A. coprolithiforme Schwager by Cushman and by Wickenden. The species shows considerable variation and may have a fairly long range.

Veinouilina cf. canadensis Cushman

Gaudryina sp.

Milliammina cf. manitobensis Wickenden

It is probable that there are other zones in higher beds, but as the continuous series of samples only covered the lower 165 feet, these were not recognized.

Pelican Formation

The name Pelican was applied by McConnell (1893, pp. 28, 29) to two distinct lithologic members, the Pelican sand and the Pelican shale. As the use of a lithological term as part of a formational name is not considered good practice, it seems advisable to separate these distinct types into two formations, retaining the name Pelican for the sand formation, which is first exposed in the river valley at Pelican Rapids. Exposures of the Pelican occur at various places along the valley from Pelican Rapids to about 6 miles below Joli Fou Rapids in $\frac{N}{2}$ tp. 82, rge. 17. It is an easily recognized formation, and should serve as a very useful horizon marker for tracing structure and geological mapping.

The thickness of the Pelican is about 40 feet. It is composed mostly of light grey to white sand, with variable lenses of dark grey

shale. Pebble zones occur in various parts of the formation in different localities, although they are most common near the top of the formation. The presence of glauconite in much of the sand and the occurrence of an ammonite at one locality indicate that the beds are of marine origin, although here and there small concentrations of carbonaceous or coaly material were observed, indicating that a source of vegetable matter, probably land plants, was not far distant.

Sections that show some variation in composition were studied at two localities. One showing many shale beds was measured on the northwest of a very sharp bend in the river side in SE.$\frac{1}{4}$ sec. 19, or SW.$\frac{1}{4}$ sec. 20, tp. 80, rge. 17, W. 4th mer.

	Thickness (in feet)
Shale, lower part of Colorado group	100±
Sand, light grey, medium grains; some brown staining near top; some crossbedding at 9 feet down; some thin ironstone concretions and 3 to 4 inches of sand with chert pebbles in lower 1$\frac{1}{2}$ feet, with concretions and shaly nodules; a small tooth of a shark found here	21
Shale, dark grey, with many lenses of grey sand	1.3
Sand, light grey, fine grains; mostly quartz, with some chert grains	0.3-0.4
Shale, dark grey; few lenses of light grey sand in lower part and at top; lenses 1 inch to 2 inches thick	3.2
Sand, very light grey to white, medium to fine grains; mostly quartz; some black chert grains; some brown stained zones; some thin beds or lenses of dark grey shale	3.5
Concretion, ironstone, hard	0.4-0.5
Shale and sand, dark and light grey in alternating beds	0.5
Sand, light grey, fine grains	0.5
Sand, light grey, with thin lenses of dark grey shale	0.4
Shale, dark grey to black, fairly dense; few zones encrusted with ochre or melanterite	0.3
Sand, very light grey, fine-grained; mostly quartz, some black chert grains; few thin lenses of dark grey shale	0.5

	Thickness (in feet)
Shale, dark grey; a little encrustation of melanterite or ochre	0.4
Sand, medium to light grey, very fine grains; some glauconite; some lenses of dark grey shale	0.8
Shale and silty sand, dark, medium grey to light grey, interbedded in many thin lenses	3.0
Sand, light grey to white, medium grains; well rounded to angular quartz and chert; $\frac{1}{2}$ inch band of dark grey shale 1 foot above base	2.2
Sand and shale interbedded and in lenses; white quartz sand with some well-rounded chert grains; shale, dark grey; some carbonaceous streaks	0.7
Sand, light grey to white, medium to fine grains, mostly quartz; some chert	0.75
Shale, dark grey	0.1
Sand, light grey, base in dark grey shale	0.7

The lowermost 5 feet of beds were observed by digging a pit, and it is not certain that the dark grey shale at the bottom is the underlying shale formation, although the total thickness of 40.5 feet indicates that it probably is.

The base of the section was about 50 feet above water level, and from this it is assumed that the top of the Pelican is about 1,475 to 1,480 feet above sea-level at this locality.

The great detail of the measured section was given to indicate the relationships of the sand and shale. A much less shaly section of the Pelican was studied about 8 miles farther downstream on the east side of the valley at Joli Fou Rapids. This section is about in NW.$\frac{1}{4}$ sec. 33, tp. 81, rge. 17, W. 4th mer. A considerable area in this vicinity shows exposures, some of which are in place and some slumped. The Pelican formation is exposed best near the southern end of the area of exposures. There the base of the Colorado group, the Pelican formation, and the top of the underlying Joli Fou formation are exposed and the following section was measured.

	Thickness (in feet)
Clay till	20±
Colorado group	
Shale, dark grey, non-calcareous; few sandy layers; ochre encrustations	15 - 20
Pelican formation	
Sand, light grey, with some dark grey shale beds and some concretions; sand partly cemented; grains medium to fine, mostly quartz, some chert; a few small chert and quartz pebbles	2.7
Sand and sandstone, light grey to brownish, with some shaly beds, especially near base	0.7
Sand, light grey and brown, partly cemented at top with ferruginous cement; medium to fine grains, mostly quartz, subangular; a few scattered partings or thin lenses of dark grey shale occur in this sand member	21.6
Sand, light grey, with many dark grey shale beds	1.5
Sand, light grey, fine grain, with few thin beds or partings of dark grey shale	5.8
Sand and shale in alternating beds, light grey and dark grey; shale beds 3 to 4 inches thick, sand beds up to 1 foot	2.0
Concretion and cemented sand, brown; one fragment of ammonite collected here	0.5-0.7
Sand and shale, light and dark grey, in alternating beds about 3 to 4 inches thick	1.5
Shaly sand, medium to light grey, somewhat mottled, in irregular lenses of sand	8.0
Joli Fou formation	
Shale, medium grey, becoming darker towards base; somewhat sandy; some glauconite; a few foraminifera	4.5
Shale, dark grey to black; some pyrite; somewhat blocky fracture; a little melanterite or ochre on joint faces; some foraminifera	17.0

The lower 15 feet were observed by digging a trench through material that had slid off the high parts of the exposed section.

The only indication of the age of the formations is the fossil that was found in this section. The fragment of an ammonite was studied by F.H. McLearn of the Geological Survey, who reported as follows:

"The preservation is poor. It may be a Placenticeras although the suture line is simpler than any known typical species of this genus. An early Upper Cretaceous age is suggested".

The base of the Pelican formation is arbitrarily placed at the base of the 8-foot shaly sand zone. The position of the formation with relation to the shales above and below and the microfaunal succession in these shales indicate that it is correlative with the Viking sand farther south in the Alberta Plains, and it is probable that the two merge. If so, the name Pelican might be applied throughout as it has seniority.

Joli Fou Formation

The name Joli Fou has been chosen by the writer for the shale formerly called the Pelican shale, because exposures in the vicinity of Joli Fou Rapids show both the top and bottom of the formation as well as some of the intervening beds. The top of the formation occurs at river level a short distance below Stony Rapids, but a talus of loose sand from the overlying formation obscures the upper shale beds at most localities. Although the formation is only about 110 feet thick it has such a tendency to slump that no one exposure shows a complete section. Near Joli Fou Rapids, the upper, some of the middle, and the lowest beds in the formation can be observed. Some of the beds at the top of the formation have been described in discussing the Pelican formation. The upper part of the formation was also studied at a locality about 5½ miles below Joli Fou Rapids, in NW.¼ sec. 22, or SW.¼ sec. 27, tp. 82, rge. 17, W. 4th mer. At this locality the following section was measured, and will be referred to as Joli Fou section No. 1:

	Thickness (in feet)
Glacial drift	10±
Joli Fou formation	
Sand, with minor shale beds of Pelican formation; not measured in detail	40±

	Thickness (in feet)
Sand, shaly, or sandy shale, with irregular lenses of sand	8.0
Concretion, sandy, weathers rusty	0.06
Shale, sandy, dark grey; some glauconite in sand	3.0
Shale, dark grey to black, fairly tough	15.45
Concretionary silt, medium grey	0.2
Shale, dark grey	22.0
Sand and sandy shale, with chert pebbles up to 1 inch in diameter	5.0
Shale, medium to dark grey, somewhat bluish in fresh wet sample	6.0

The sandy zone with chert pebbles, near the base of this section, may be the same as the sandy zone in the top of the next described section (Joli Fou No. 2) lower in the formation, which was studied near Joli Fou Rapids in the north-central part of the series of exposures on the east side of, and about 200 feet back from, the Athabasca in the west-central part of sec. 33, tp. 81, rge. 17, W. 4th mer. At this locality the following section was measured:

	Thickness (in feet)
Till	5-6
Joli Fou formation.	
Shale, dark grey, non-calcareous	1.0
Concretion, light grey, replaced by silt along the bedding; fragment of Inoceramus	0.5
Shale, dark grey; some thin, light grey silt beds	7.3
Shale, sandy, medium to dark grey; some lenses of sand	1.25
Shale, dark grey; few thin silt beds	24.0

The base of this section is about 24 feet above the top of the Grand Rapids formation exposed at the water's edge about 200 feet distant.

The basal part of the Joli Fou formation was studied in an exposure about 8 miles downstream from Joli Fou Rapids, on the east side of the valley in NW.¼ sec. 35, tp. 82, rge. 17, W. 4th mer., about 140 feet above the river. The locality is about 150 feet south from, and a little higher than, a very prominent section of the upper part of the Grand Rapids formation described later in this report. At this locality Joli Fou section No. 3 was measured as follows:

	Thickness (in feet)
Glacial drift	5+
Joli Fou formation	
Shale, medium to dark grey, with irregular lenses of light grey silt; some ochreous encrustations or melanterite; few fragments of Inoceramus shells	11
Shale, dark grey to black; many fragments of Inoceramus; some ochreous or melanterite encrustations; some buff weathering concretions	2
Shale, sandy, becoming sandy shale in lower half; medium to dark grey; few chert pebbles; some slabs ½ to 1 inch thick of lignitized wood	2
Concretion, grey, ironstone	5.5
Grand Rapids formation	
Shale, sand, and silt in thin alternating beds up to 6 inches; weathers brown to yellow; some traces of carbon	8

An attempt was made to collect some fossils from the beds in the middle of this section. Part of one specimen of a very large, thin, Inoceramus shell was uncovered, but this was too poorly preserved to be collected. This specimen was 21 inches long and at least 10 inches wide. The shell at the outer margin was only about 1/16 inch thick, but at the hinge it was about ¾ inch. Judging from pictures taken of the specimen, F.H. McLearn offered the following opinion:

"The large specimen in the photograph shows at least a superficial resemblance to the Lower Cretaceous species Inoceramus altifluminus".

A few specimens of a smaller species of Inoceramus were collected, but the preservation was too poor to determine the species.

Samples were collected from all exposed sections of the Joli Fou formation, and foraminifera were found in them all. All specimens belong to arenaceous genera, and only tentative identifications have been made so far; these may, however, be useful for comparative and correlative purposes. The following list is given to indicate the most common species and some of their characteristics:

Hyperammina sp. - a small white species with some irregular constrictions.

Reophax sp. - a medium-sized tapering test with comparatively coarse grains of sand.

Ammodiscus sp.

Glomospira cf. watersi Loeblich

Trochamminoides sp. - a species somewhat similar to T. valascoensis Cushman, with fewer and proportionally larger chambers in each coil.

Haplophragmoides sp. A - a small, white, involute species, with about 8 to 10 chambers in the last coil; most specimens badly crushed.

Haplophragmoides sp. B - a medium to small, somewhat evolute species, much like H. bearpawensis Wickenden; sutures are somewhat sigmoid.

Haplophragmoides cf. cushmani Loeblick and Tappan - this species is very similar to that described from the Washita group except that it is larger - 0.6 mm.

Haplophragmoides gigas Cushman

Ammobaculites A - a fairly large species a little more than 1 mm. in length with an oval cross-section; with coarse-grained walls and indistinct chambers and sutures.

Ammobaculites B - medium-sized species with nearly circular cross-section; coiled part about same width as rectilinear part; medium grain; fairly well cemented, distinct sutures.

Ammobaculites C - a fairly large species varying from a little less to more than 1 mm. in length; somewhat flattened sides; chambers in rectilinear part tend to overlap in some specimens, resembling the genus Flabellammina; walls medium to coarse grained, fairly well cemented.

Ammobaculites D - a fairly long, narrow species (about 1 by 0.2 mm.); chambers in coiled part not very distinct owing to fairly coarse sand grains in test; about 3 to 4 chambers in rectilinear part.

Ammobaculoides sp. - this species shows some resemblance to A. gainsvillensis Loeblich and Tappan, but is larger. The sutures are less distinct, and the sand grains are coarser.

Spiroplectammina sp. - this looks very much like the species described and figured by Loeblich from the Pepper shale, but the Canadian species is larger, some specimens being 0.8 mm. in length.

Textularia sp. - a small white species with walls of very fine material.

Gaudryina canadensis Cushman

Gaudryina sp. - similar to G. canadensis but more blunt; fewer chambers in biserial part; coarser grains in walls, with little cement.

Milliammina cf. manitobensis Wickenden

Trochammina ? sp. - this is a coiled species, in which chambers of the last coil nearly completely cover the previous coils on the ventral side and only cover part of the previous coil on the dorsal side, so that part of all the chambers is visible on the dorsal side; chambers globular; walls fairly thin; fine-grained aperture; a low slit at the base of last found chamber near the periphery on the ventral side.

The listed foraminifera do not prove the age of the formation, but some relationship is shown to the late Lower Cretaceous and early Upper Cretaceous of Texas and Oklahoma. The fossils are useful for correlation in much of the Plains area of Canada, and their occurrence in the different parts of the sections is shown in Table I. The same sequence of species has been observed in part in wells near Lloydminster and Unity, Saskatchewan, below the Viking sand and above the Mannville formation. This indicates that the Joli Fou formation extends into those parts of the Plains at least.

Table I

Section	Sample Number	Hypeammina sp.	Reophax sp.	Ammodiscus sp.	Glomospira cf. watersi Loeblich	Trochamminoides sp.	Haplophragmoides sp. A	Haplophragmoides sp. B	Haplophragmoides cf. Cushmani Loeblich and Tappan	Haplophragmoides gigas Cushman	Ammobaculites sp. A	Ammobaculites sp. B	Ammobaculites sp. C	Ammobaculites sp. D	Spiroplectammina sp.	Ammobaculoides sp.	Textularia sp.	Gaudryina Canadensis Cushman	Gaudryina sp.	Milliammina cf. manitobensis Wickenden	Trochammina ? sp.
Section No. 1	1										X										
	2						X														
	3						X													X	
	4						X													X	
	5				X		X													X	
	6				X		X													X	
	7				X		X													X	
	8	X	X		X		X	X				X								X	
	9	X	X				X	X				X		X						X	
	10	X	X				X	X				X		X						X	
	11						X		X				X	X						X	
	12						X		X											X	
Section No. 2	1						X		X				X	X						[illegible]	
	2						X		X				X	X							
	3						X													X	
	4						X											X		X	
	5						X	X										X			?
	6						X	X		?				X				X	?		X
	7						X	X		?				X				X	X		X
Section No. 3	1						X	?	X	X				?		X		X	X		
	2					X	X	X	X	X			?	X	X	X	X		X		
	3						X		?	X			X	X	X	X	X		X		
	4						X			X						X					
	5															?					
	6									X											

The above table shows the distribution of foraminifera in exposed sections of the Joli Fou formation; each sample represents 5 feet of beds except Section No. 3, samples 3 and 4, which represent 3 and 2 feet respectively.

Grand Rapids Formation

The Grand Rapids formation was observed between the Joli Fou Rapids in secs. 28 or 29, tp. 81, rge. 17, to sec. 30, tp. 85, rge. 17, W. 4th mer. Outcrops are scattered in this part of the valley, and various parts are not well exposed. The lowest 30 feet are exposed on the west side of the river in sec. 30, tp. 85, rge. 17, W. 3rd mer. The thickest section exposed can be seen near the head of Grand Rapids on the west side of the valley a short distance south of Loon Creek. Between a point about a mile above Grand Rapids and the junction with House River, about 9 miles farther upstream, exposures are poor, although detailed examination would probably reveal sufficient key beds to trace structure. At the junction of House River and the Athabasca, and at several points along House River, some outcrops expose about 50 to 60 feet of the Grand Rapids formation. The upper part is well exposed about 5 miles above House River on the east side of the Athabasca in NW.$\frac{1}{4}$ sec. 35, tp. 82, rge. 17, W. 4th mer. From this point to Joli Fou Rapids, various small sections of the upper part of the formations are exposed. These show considerable slumping, and no detailed studies were made of them. The last exposure upstream are found on the east side of the river near the middle of Joli Fou Rapids, in about NW.$\frac{1}{4}$ sec. 28, tp. 81, rge. 17, W. 4th mer.

The Grand Rapids formation can be divided into lithological members as follows:

	Thickness (in feet)
Sand, silt, and few shale beds	80
Gap ?	?
Coal	4±
Sand, light grey to white, medium to fine grained	40
Sand, silt, and shale in alterating beds; some zones with many chert pebbles; some marine silt and shale beds	105
Sand, light grey, 'pepper and salt', with many very large lenticular or spheroidal cemented or concretionary masses especially in lower half; probably mostly marine	130±

Only the upper 80 feet were examined in detail, and the exact relationship of this part to the coal bed is uncertain. The coal was not seen in exposures more than a mile above Grand Rapids, and between this locality and the one where the detailed section was measured, about 12 to 13 miles upstream, there are few exposure where detailed relationships can be studied. It seemed to the writer that the heavy sand or sandstone bed beneath the coal is the same as that in the exposures at the mouth of House River, and underlies 80 feet of sand, silt, and shale at the top of the formation with a gap of not more than 20 feet between. There was no indication of coal or carbonaceous shale above this sand and sandstone, and if the relationship suggested is correct, the coal lenses out between Grand Rapids and House River or has been completely covered by slumped beds. More detailed study is needed to be certain of the relationship here.

The upper part of the formation was studied on the east side of the Athabasca about 4 to 4½ miles above House River, in NW.¼ sec. 35, tp. 82, rge. 17, W. 4th mer.

	Thickness (in feet)
Slumped shale, dark grey.....	8-10
Shale, dark grey to black, with yellow ochre encrustation in parts, some foraminifera; base of Joli Fou formation.....	1.2
Silt, medium to light grey, thin bedded, much cross-bedding; some ½- to 3-inch beds or lenses of carbonaceous shale or silt.....	2.5
Silt, medium grey, somewhat shaly near base; some thin lenses of light grey silt and a little 'salt and pepper' sand, with glauconite; a few small chert pebbles; a few fragments of fossil fish.....	4.7
Shale, dark grey, soft, with lenses or inclusions of light grey silt; a few small chert pebbles; a few fragments of fossil fish; a few foraminifera	2.5

	Thickness (in feet)
Sand, light grey to yellowish, fine grained, composed of chert and quartz; many chert pebbles in upper 6 to 8 inches; a few lenses of lignite; a trace of glauconite; lower 8 inches medium grey silt bed.....	4.5
Sand, silty, and sandy silt, medium to light grey; somewhat greenish; some partly cemented zones with 'sideritic' cement, and some granular, sideritic material in upper part; some thin beds of shale, especially near the top; lower 5 feet somewhat clayey; few chert pebbles.....	10.5
Concretion, brown weathering, ironstone.....	0.3-0.5
Sand, light grey to yellowish or greenish, fine grained, somewhat massive, crossbedded; a few chert pebbles; a little glauconite; some thin beds of medium grey shale near the top.....	8.5
Shale, medium grey, sandy; small silt lenses; a little glauconite; irregular zones of ironstone concretions up to 3 inches thick at base of shale.....	2.5
Sand, shaly, medium grey, somewhat greenish; few fragments of fossil fish; a trace of glauconite.....	2.9
Shale, dark grey; lower 6 inches silty; a few concretions 3 to 4 inches thick scattered near base; few small chert pebbles...	2.0
Sand, light grey, very fine grains; some thin, shaly and silty beds a few siltstone concretions, and a few carbonaceous streaks; some crossbedding.....	4.5
Silt, medium to light grey, mottled with clay; medium grey; occasional small concretionary or ironstone layer.....	2.0
Sand, light grey, somewhat greenish; very fine grains; some thin beds of medium grey shale; a little glauconite; becomes very silty towards base; few streaks of carbonaceous material; some ironstone concretions at base; some crossbedding..	9.5

	Thickness (in feet)
Silt, medium grey, somewhat mottled with light grey, becomes shaly towards bottom; few foraminifera and fragments of fossil fish.....	2.1
Shale, dark grey streaks; many crushed shells of pelecypods and gastropods near base; some foraminifera and fragments of fish bones.....	1.8
Silt, medium grey, somewhat sandy; becomes shaly; somewhat mottled and darker in lower foot; some crossbedding; a few fragments of fossil fish.....	3.9
Sand, medium to light grey, very fine grains, few carbonaceous and shale streaks; becomes silty towards base; some crossbedding; one specimen of foraminifera.....	4.0
Silt, medium and light grey, in streaks; some scattered fine grains of carbon; a little glauconite; this silt slumps very easily.....	10.0

The base of the section is more than 40 feet above river level, but slumping of the beds that form the section has covered the bank down to water level. Apparently a fairly thick sand member lies a few feet below the section. The exact thickness and character of the beds between the sand member and the base of the section were not ascertained, but it is probable that they do not exceed a few feet.

The occurrence of glauconite and foraminifera in various beds in the foregoing section are taken as evidence of marine or brackish conditions. The fragments of fish bones are so often associated with the glauconite and foraminifera that they, too, may have been marine fishes. On the basis of these criteria, most of the sediments in the upper part of the Grand Rapids formation at this locality were deposited in marine or brackish waters.

The top of the Grand Rapids formation at this place is about 123 feet above river level. If an average fall of $4\frac{1}{2}$ feet per mile is assumed between this place and the crossing of the twenty-first base line, about 15 miles upstream, the elevation of the contact is about 1,313 feet above sea-level. These figures are only approximate, and will need to be revised.

The part of the Grand Rapids formation below the section described was not studied in detail. Most of the beds are well exposed just above Grand Rapids on the west side of the River, in SW.¼ sec. 34, tp. 84, rge. 17, W. 4th mer. The highest part of the well-exposed section is a coal or lignite seam about 4 feet thick. About 100 yards from the well-exposed section, and at an elevation about 30 feet higher on the wooded slope of the valley, a slumped exposure of the basal beds of the Joli Fou formation was observed. Considering the fact that shale beds of this type were observed to be more than 100 feet out of place in other localities, it is probable that these beds have slumped at least 50 feet. As no carbonaceous shale or coal that might compare with the coal seam mentioned was observed in the section of the upper part of the Grand Rapids formation already described, and as the underlying heavy sandstone appears to rise in the banks of the river from the vicinity of House River to Grand Rapids, it is probable that the coal seam and the beds underlying it occur below this section. There may be a gap between these two sections, but it is doubtful if it is more than 10 or 20 feet. McConnell (1893, p. 29D) considered that the coal seam marked the top of the Grand Rapids formation at Grand Rapids, although he recognized the true top of the formation above Joli Fou Rapids and that the coal seam was not present there.

Below the coal is a massive sand bed about 40 feet thick, which weathers light grey to cream or nearly white. The writer thinks that this sand, or partly consolidated sandstone, is the same as the one exposed on House River at the junction with the Athabasca, although the House River sand is greyer than that at Grand Rapids. However, exposures about half a mile up House River show whiter and more cream-coloured sand, and the difference may be due to weathering or to the direction faced by the exposures. The sand is composed of medium to fine grains, and some silt occurs between the grains in places.

Below the 40 feet of sand at Grand Rapids are about 105 feet of sand, silt, and minor shale beds. Sand beds predominate and vary in thickness from a few inches to about 10 feet. Several beds carry numerous chert and quartz pebbles, most of them an inch or less in diameter. The silt beds are less numerous than the sand beds, and most of them are less than 5 feet thick. The shale beds are thin and few; near the top and middle of the section they may be 3 to 4 feet thick, and may be in part composed of shaly silt. Carbonaceous material occurs in zones in a few shale beds and as streaks in some of the silts and sands. Grab samples from the shale beds yielded foraminifera indicating their marine origin. Undoubtedly, too, some of the sand and silt beds are marine, as in the upper part of the section already described.

The lower part of the section at the head of Grand Rapids consists of about 95 to 100 feet of sand and sandstone, in the lower part of which are numerous, massive, lens-shaped or roughly spheroidal, cemented masses of sandstone that form most of the boulders in the rapids. The sand is mostly of the medium to fine grain, light grey, 'salt and pepper' type. Some zones show crossbedding, and lenses of chert-pebble conglomerate or conglomeratic sandstone are fairly common in the sandstone. The pebbles vary in size up to 1 inch or 1½ inches, and are mostly of black chert with a few of green or grey chert.

Marine pelecypods occur in some of the cemented sand lenses as mentioned by McLearn (1917, p. 148). It is probable that most of the lower sand member is of marine origin.

The lowest part of the Grand Rapids formation was examined on the west side of the river about 5 miles below Grand Rapids, in NE.¼ sec. 30, tp. 85, rge. 17, W. 4th mer., where 30 to 50 feet of sandstone carry massive sandstone concretions. Some of the higher beds are also exposed, partly in the valley of a small tributary creek. The lower part is the

continuation of massive sandstone described at the base of the section above Grand Rapids. A few fossils were collected from a large sandstone concretion just above the base of the formation. These fossils have been identified by F.H. McLearn as:

Pecten (Entolium) irenense

Pecten n.sp. ?

Nucula ? sp.

He commented on these identifications as follows: "The P. (Entolium) irenense occurs in the Clearwater shale. The Pecten n.sp.?, is not P. alcesiensis from the Clearwater shale". These fossils indicate that the contact between the Clearwater and Grand Rapids does not mark a sharp break or change in conditions of sedimentation nor in the environment for the animals living in the sea at that time. If this change were gradual, the position of the contact may not represent the same time from place to place.

Some indication of the thickness of the basal sand member of the Grand Rapids formation was obtained at the locality in sec. 30, tp. 85, rge. 17, W. 4th mer. The base of the coal bed overlying the upper heavy sand was 280 feet above the Grand Rapids-Clearwater contact, and at Grand Rapids the coal seam was about 145 feet above the top of the basal sand member. The difference of 135 feet is probably the thickness of this basal sand member. At the locality in section 30, a bench in the side of the valley at about 145 feet above the contact was covered with trees and bush and its origin could not be determined, but it appears to be related to a change in the underlying formation such as the contact between the basal sand member and the overlying alternating sands, silts, and shales. Its elevation above the top of the Clearwater shales represents the approximate thickness of the basal sand member of the Grand Rapids formation.

The age and correlation of the Grand Rapids formation are based chiefly on its position in the section and on its lithological characteristics. Its position below the Joli Fou and above the Clearwater indicates an Albian (late Lower Cretaceous) age in European chronology. No diagnostic animal or plant fossils have been reported from the formation, although it is probable that some will be found if detailed studies are made.

On the basis of lithology and position below the Joli Fou formation, the Grand Rapids correlates with some of the Mannville formation in the vicinity of Vermilion and Lloydminster in east-central Alberta and west-central Saskatchewan. The members of the Mannville observed by Nauss (1945, pp. 1609-1615) are not recognized on the Athabasca, but it is possible that the Grand Rapids is equivalent to the Islay member and all those above it. The lithological sequence and the predominance of marine beds throughout the Grand Rapids make it difficult to correlate more accurately with the sections studied farther south where marine beds are few. Probably, sediments were deposited in the different areas under conditions that changed from marine to deltaic or fluviatile in varying degree. These sediments probably all formed at the same time to comprise a formation characterized by a lack of lithological uniformity.

Clearwater Formation

Only the upper 10 feet of the Clearwater shale was observed where it first outcrops on the west side of the river, NE.$\frac{1}{4}$ sec. 30, tp. 85, rge. 17, W. 4th mer. At this locality the shale is soft, slightly sandy, with some glauconite and some large septarian concretions. The samples collected contain a fair number of arenaceous foraminifera, including species of Haplophragmoides, Ammoloculites and Gaudryina.

STRUCTURE

A little general information on structure was obtained in the course of this investigation, though to what extent details can be worked out is uncertain. Several horizon markers could be traced, but apart from the main valley few outcrops occur on tributary streams. Throughout most of the area the beds dip southerly; differences in elevation indicate that this dip is about 10 feet to the mile. At Grand Rapids, a reversal of dip may indicate part of a closed structure. The base of the Grand Rapids formation, near the head of the rapids, is calculated to be 30 to 40 feet below water level. About 5½ miles downstream, the same beds occur at water level. The surface elevation at the latter location is about 75 feet lower, indicating a northerly dip of about 7 feet to the mile. Above Grand Rapids, the southerly dip seems to be about 10 feet to the mile. It might be possible to determine the dip west of Grand Rapids by studying exposures on Loon Crook. No fair-sized valleys enter from the east in this vicinity.

There may be other locations where similar structures exist. The fact that gas has been found at Pelican and at House River in sufficiently large quantities to supply local needs for more than 30 years may also indicate locations where high structures exist.

In trying to determine structures it seems probable that the Grand Rapids-Joli Fou contact, the top of the Pelican formation, the fishbone beds about 100 feet above the top of the Pelican, and the Colorado group-Lea Park contact, are all horizons that are extensive and uniform in the area. Other reliable horizons may exist between the top of the Colorado group and the fishbone bed, but more detailed study is required to reveal these.

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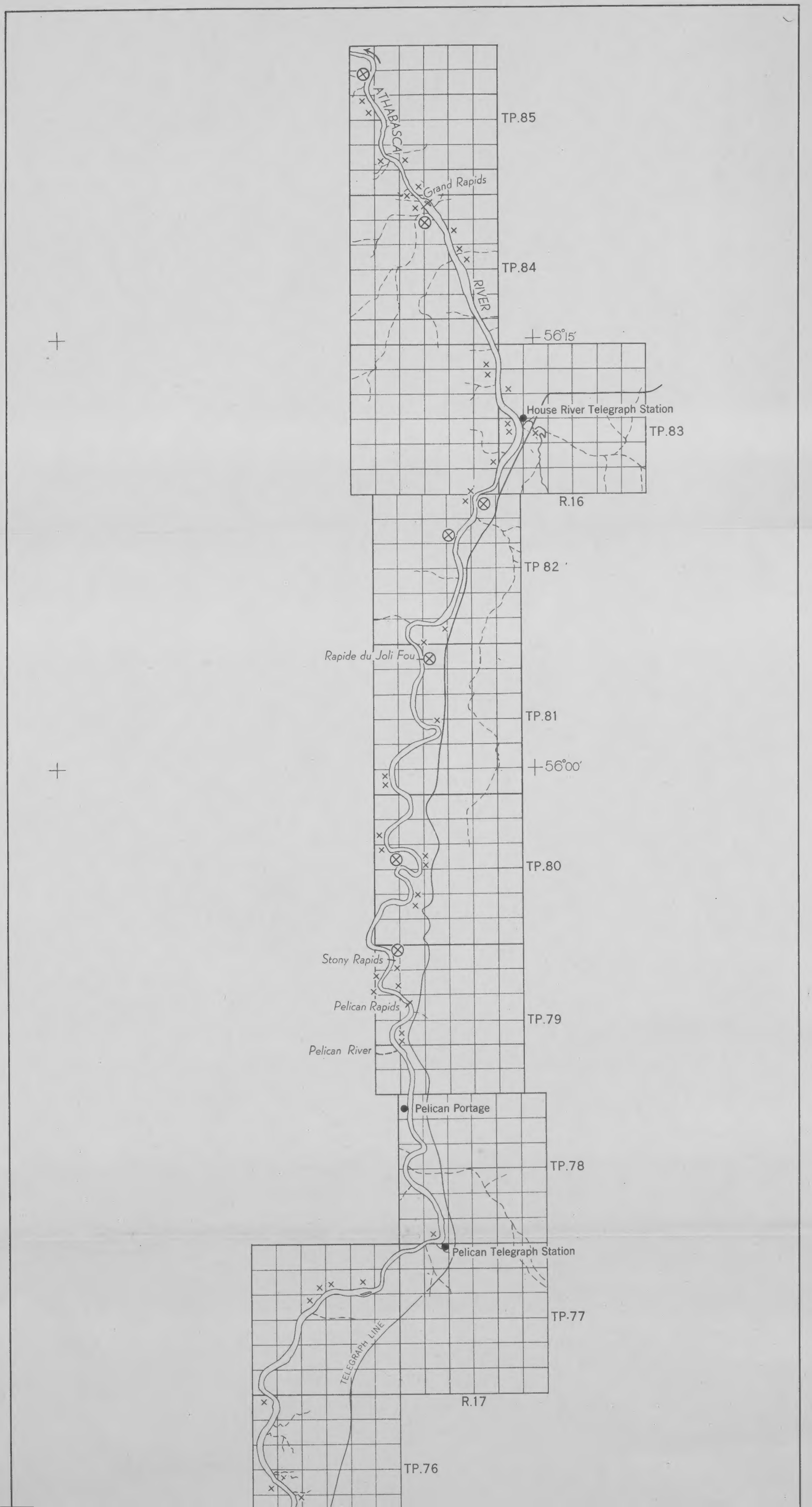
ATHABASCA
RIVER
Grand Rapids
TP.85
TP.84
56°15'
House River Telegraph Station
TP.83
R.16
TP 82
Rapide du Joli Fou
TP.81
56°00'
TP.80
Stony Rapids
Pelican Rapids
TP.79
Pelican River
Pelican Portage
TP.78
Pelican Telegraph Station
TP.77
TELEGRAPH LINE
R.17
TP.76

Stony Rapids

Pelican Rapids

Pelican River

TP.79

Pelican Portage

TP.78

Pelican Telegraph Station

TP.77

TELEGRAPH LINE

R.17

TP.76

TP.75

55°30′

Iron Point

TP.74

Duncan Creek

TP.73

Red Mud

Swift Current

TP.72

RIVER

R.18

TP.71

ATHABASCA

Calling River Telegraph Station

TP.70

R.19

WEST OF FOURTH MERIDIAN

113°00′

55°00′

112°30′

CANADA

DEPARTMENT OF MINES AND RESOURCES

MINES, FORESTS AND SCIENTIFIC SERVICES BRANCH

GEOLOGICAL SURVEY OF CANADA

Figure 1.

Sketch map of area along Athabasca River in Alberta, showing positions of bedrock outcrops (×) and geological sections examined (⊗).

To accompany Paper 49-15 by R.T.D. Wickenden

Scale: 1 Inch to 4 Miles

4 0 4 8